Woody plants play an important role in determining the physical structure of many riparian ecosystems (Gurnell, Bertoldi & Corenblit 2012). Understanding the responses of woody riparian plants to environmental stresses is therefore central to river rehabilitation and riparian conservation efforts.

To thrive near stream channels, plants must navigate a trade-off between ease of access to water and stresses associated with waterlogging or inundation (Naiman, Decamps & Pollock 1993; Colmer & Voesenek 2009). Woody colonists of inset channel features such as bars and benches may experience repeated cycles of soil waterlogging (Corenblit *et al.* 2009), restricting root access to oxygen (Voesenek & Bailey-Serres 2015). Maintaining root respiration in low O2 conditions requires switching to costly anaerobic metabolic pathways (Drew 1997). Reduced respiration weakens root function, impairing uptake of water and nutrients (Piedade *et al.* 2010; Voesenek & Bailey-Serres 2015), and induces suberisation (Steudle 2000). Stomatal closure may also take place following waterlogging, reducing available CO2 for photosynthesis (Kozlowski 1984; Else *et al.* 2009). Root-zone hypoxia damages roots by disrupting aerobic respiration and causing an “energy crisis” (Colmer & Voesenek 2009); reactive oxygen specices (ROS) then form as biproducts of anaerobic metabolism (Santosa *et al.* 2007). Subsequent reaeration further increases ROS production (Steffens, Steffen-Heins & Sauter 2013). Production of toxic ions by microbes under anoxic soil conditions causes additional stress to roots (Blom & Voesenek 1996). Waterlogging may also impair rhizomicrobial nodule formation and activity (Dawson, Kowalski & Dart 1989; Shimono *et al.* 2012), resulting in reduced nutrient uptake. The degree to which this combination of stressors influences plant growth is ultimately determined by species’ ability to mobilise physiological and morphological responses which mitigate damage (Bailey-Serres & Voesenek 2008).

Atmospheric CO2 has risen substantially over the past century, and a doubling of pre-industrial levels by 2100 is projected (IPCC, 2013). As with waterlogging, atmospheric CO2 concentration is known to affect plant physiology and growth by altering the fundamental economics of carbon, water and macronutrient uptake and use (Poorter & Navas 2003; Wang *et al.* 2012; Reich, Hobbie & Lee 2014). Individual species responses are variable, but photosynthetic CO2 assimilation in C3 plants tends to increase under eCO2 (Curtis 1996). Stomatal conductance is also typically reduced (Ainsworth & Rogers 2007), with attendant gains in water use efficiency (Holtum & Winter 2010; Keenan *et al.* 2013; van der Sleen *et al.* 2014). Biomass accumulation in response to eCO2 may be enhanced (Wang *et al.* 2012), but depends on the availability of water and macronutrients (Körner 2006; Manea & Leishman 2014; Reich *et al.* 2014). Increased allocation of biomass to roots occurs under eCO2 (Nie *et al.* 2013), although this effect is interactive with environmental stresses such as drought or low soil fertility (Wang & Taub 2010). Increased rates of production and turnover of fine roots under eCO2 have been shown in the field, which has important implications for nutrient cycling and ecosystem functioning (Pregitzer *et al.* 1995, 2000; Matamala & Schlesinger 2000; Lipson *et al.* 2014). eCO2 is also known to affect functional traits indicative of positions along economic spectra (*sensu* Reich 2014). Reduction in specific leaf area (SLA) under eCO2 has been linked to accumulation of non-structural carbohydrates in leaves (Poorter & Navas 2003; Bader, Siegwolf & Körner 2010). Alteration of traits reflecting economic trade-offs is of particular significance at the seedling stage, as functional traits of trees are most strongly adapted to the regeneration niche (Poorter 2007).

Taken individually, waterlogging and elevated atmospheric CO2 concentration appear to exert opposing effects on plant growth. The possibility that eCO2 may mitigate growth reduction under waterlogging warrants investigation of the interactive effects of these two environmental variables. Literature describing interactive effects of atmospheric CO2 concentration and waterlogging or flooding on plant growth is sparse, and findings thus far present an inconsistent pircture. Megonigal et al. (2005) showed that eCO2 stimulated biomass production in waterlogged (water table at -10 cm) but not inundated (water table at +5 cm) juveniles of the flood-tolerant tree species *Taxodium distichum*. Increased photosynthesis under eCO2 was not reduced by inundation. This effect was attributed to the increased metabolic cost of maintaining roots under low O2 conditions. In the same study, inundation had no effect on eCO2 stimulation of photosynthesis or biomass production of the aquatic herbaceous species *Orontium aquaticum*. The opposite response was found for a highly flooding tolerant Amazonian tree: waterlogged *Senna reticulata* grown in open top chambers showed greater increment in biomass under elevated CO2 (Arenque *et al.* 2014). Finally, no evidence for an interaction between CO2 concentration and waterlogging status was found on growth or stomatal conductance in soybean (Shimono *et al.* 2012). To our knowledge, no studies have investigated the effects of eCO2 on recovery from waterlogging. Recovery following stress events may be more important to fitness than tolerance of the stress (Gutschick & BassiriRad 2003). For waterlogged plants, generation of reactive oxygen species following reaeration is likely to be a significant additional stress (Drew 1997).

The objective of this study was to investigate interactive effects between eCO2 and waterlogging on gas exchange, biomass accumulation and allocation, and functional traits for three riparian tree species. In particular, we were interested in whether eCO2 mitigates growth reduction under waterlogging, and whether this response is sustained following a refractory ‘recovery’ period during which soils are reaerated. We also investigated two hypothesised mechanisms by which such an interactive effect might occur: a.) higher water use efficiency under eCO2 (Holtum & Winter 2010) facilitates photosynthesis in plants with anoxia-impaired root functionality by lowering the water cost of carbon assimilation; b.) eCO2 facilitates biomass recovery by increasing rates of fine root production during the recovery period (Pregitzer *et al.* 1995).